

CRITICAL THINKING PROCESS IN GEOGEBRA-ASSISTED PROBLEM SOLVING

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Received 10 May 2024; Received in revised form 11 June 2024; Accepted 24 July 2024

ABSTRAK

Perkembangan dunia di abad ke-21 ini telah mendorong pemerintah dalam peningkatan sumber daya manusia dengan kemampuan berpikir kritis dan berkomunikasi terutama pada siswa dalam pembelajaran matematika. Namun, faktanya kemampuan berpikir kritis siswa masih rendah. Tujuan penelitian ini untuk mengetahui proses berpikir kritis siswa dalam pemecahan masalah berbantuan Geogebra. Jenis penelitian ini adalah kualitatif dengan menggunakan studi kasus, subjek penelitian ini yaitu 3 siswa kelas VIII SMP. Pengumpulan data menggunakan tes berpikir kritis dan wawancara. Data yang diperoleh kemudian dianalisis dengan tahap kondensasi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa (1) proses berpikir kritis siswa dengan kategori berhasil, siswa mencapai semua indikator proses berpikir kritis interpretasi, analisis, evaluasi, inferensi, eksplanasi, dan regulasi diri dengan baik. (2) proses berpikir kritis siswa dengan kategori kurang berhasil, siswa mencapai indikator interpretasi, analisis, evaluasi dan eksplanasi dengan baik. Namun, pada tahap inferensi dan regulasi diri indikator proses berpikir kritis tidak tercapai. (3) Proses berpikir kritis siswa kategori tidak berhasil. siswa hanya mencapai indikator proses berpikir kritis interpretasi. Pada tahap analisis, evaluasi, inferensi, eksplanasi, dan regulasi diri indikator proses berpikir kritis tidak tercapai dengan baik.

Kata kunci: Berpikir kritis; geogebra; pemecahan masalah.

ABSTRACT

The development of the world in the 21st century has encouraged the government to improve human resources with the ability to think critically and communicate, especially for students in learning mathematics. However, the fact is that students' critical thinking skills are still low. The purpose of this study was to ascertain how students used the critical thinking when problem solving. Three eighth-grade junior high school students are the subjects of this qualitative case study research design. Critical thinking test and interviews are used to collection data. Following data collection, the phases of data condensation, data presentation, and conclusion drawing. were used to analyze the data. The results showed that: (1) Students in the successful category of the critical thinking process met all indicators for the the critical thinking process, including interpretation, analysis, evaluation, inference, explanation, and self-regulation. (2) Students the less successful category, achieved the indicators of interpretation, analysis, evaluation, and explanation, in their critical thinking processes. Nevertheless, indicators were not met at the inference and self-regulation phases of the critical thinking process. (3) Critical thinking process of students in the unsuccessful category think critically. Students only require the indicators of interpretation for the critical thinking process. Critical thinking process indicators were not met at the phases of analysis, evaluation, inference, explanation, and self-regulation stages, the critical thinking process indicators were not well achieved.

Keywords: Critical thinking; geogebra; problem solving.

Introduction

The development of the world in the 21st century has encouraged the government to improve human resources with the ability to think critically and communicate, especially for students in learning mathematics (Mardhiyah et al., 2021). Everyone including students is expected to achieve good critical thinking skills. Critical thinking is a person's process to analyze, evaluate and implement decisions that are in accordance with what is believed to produce rational thinking skills (Siswono, 2018). The increasingly rapid development of the era requires critical thinking skills, which are one of the skills that students must have (Rahmawati et.al., 2022). Higher order thinking skills such as creativity, and decision-making are built on the foundation of critical thinking. Facione (2015) suggests critical thinking process includes steps (1) interpretation, which is understanding the situation or information on a problem; (2) analysis, which is determining how the relationship between statements to communicate a point of view; (3) evaluation, which is assessing the suitability of further statements to assess the logical validity of the relationship between the statement and the intended question; (4) inference, which is explaining the elements needed to reach a conclusion; (5) explanation, which is describing the results of problem solving achieved through thinking supported by logic; (6) self-regulation, the ability to verify or re-examine the cognitive activities used and the results obtained.

Critical thinking plays an important role for students because this ability will help them in the problem solving process, so it will be easier for students to overcome certain problems if they have mastered critical thinking skills (Syafuruddin & Pujiastuti, 2020). Critical thinking process plays a role in student problem solving, this is also said by Peter (2012) who states that to be effective at work and in solving problems, students must be able to solve a problem and must be able to make effective decisions and be able to think critically. This shows the relationship between problem solving and critical thinking skills. Polya (2004) revealed the stages of problem solving include, understanding the problem, devising a plan, carrying out the plan, looking back.

The state of the art in this research involves a literature review on the critical thinking process of students in problem solving has been previously conducted. Fadhilah et al. (2021) research on critical thinking process of senior high school students in problem-solving of linear equations system based on Jacob & Sam's theory, the results of the research found that students' critical thinking process in solving problems has not gone well. This can be seen from students who cannot find the right answers and conclusions from the problems given because the students' critical thinking process has not been well achieved. Basri et al. (2019) research on investigating critical thinking skill of junior high school in solving mathematical problems based on Facione's theory obtained the results of critical thinking skills of junior high school students in the low category, because students have not been able to reach the critical thinking stage, which is in analyzing information in problem solving, then students also cannot provide mathematical evidence to verify the data obtained at the evaluation stage. Munandar et al. (2020) research on analysis of the impact of mathematical learning with Geogebra assistance on critical thinking ability obtained the results of using technology as a tool that can encourage students in developing their critical thinking process.

Based on this statement, the fact is that students' critical thinking skills in solving math problems are in the low category (Basri et al., 2019; Fadhillah et al., 2021). Susandi (2021) also found that there are many factors that cause low critical thinking, such as students only focusing on memorizing concepts and theories without being faced with problems that can stimulate critical thinking skills. Therefore, innovation is needed, one of which is the use of technology as a tool that can encourage students to develop their critical thinking process in the 21st century (Munandar et al., 2020). One of the software that can be utilized in solving math problems is Geogebra. Negara et al. (2022) stated that through Geogebra students can find new patterns, explore and then test their guesses, and manipulate various objects, some of the activities that students can do include designing and drawing their sketches on Geogebra. Therefore, through the use of Geogebra, students are expected to explore in solving mathematical problems so that students can optimize their critical thinking process.

Based on the previous explanation, it is important to implement technology in solving math problems. Geogebra can be a software that makes students' exploration process more fun and can affect students' critical thinking process. However, there are still few studies of critical thinking processes in problem solving using technology. Thus, this study aims to describe the critical thinking process of students in solving linear function problems assisted by Geogebra.

Research Methods

This research is a qualitative research with a case study research type. This study explores in depth critical thinking process of students with successful, less successful and unsuccessful categories in problem solving. Subjects of this study were students of class VIII junior high school in Sidoarjo. In this study, the data collection instruments used were tests and interviews. The determination of subject of this study was carried out by purposive sampling by considering the results of critical thinking test.

From the results of critical thinking test given, students who meet the criteria will be selected to become research subjects, 3 students with the provisions of 1 student who is successful in solving linear function problems, 1 student who is less successful in solving linear function problems and 1 student who is unsuccessful in solving linear function problems. Selected subjects were then given a critical thinking test with Geogebra assistance as shown in Figure 1. After subject completes the test, the next stage is the interview.

Suppose a line g passes through points $D(2,10)$ and $E(4,4)$. Line h passes through point $(2,6)$ and is parallel to line g . Abdul says that the equation of line h is $2y + 6x - 24 = 0$. Is Abdul's statement correct? Explain your reason!

Figure 1. Critical thinking test

The data obtained were then analyzed using the analysis technique of miles et. al., (2014), which are data condensation, data display and drawing and verifying conclusion according to the indicators of critical thinking in problem solving in Table 1.

Table 1. Critical Thinking Process in Problem Solving

Problem Solving	Critical Thinking Process	Indicators
Understanding the problem	Interpretation	I.1. Understand the known and required information in the problem clearly and precisely then write it in the Geogebra algebra view column. I.2. Reveal the point that is the main problem in the problem.
Devising a plan	Analysis	A.1. Connecting information with concepts that will be used in problem solving by exploring the tools in Geogebra. A.2. Consider reasoning related to relevant information that will be used in problem solving.
Carrying out the plan	Evaluation	E.1. Determine the steps used in problem solving. E.2. Evaluate the exploration process conducted on Geogebra.
	Inference	F.1. F.1. Identify the problem solving steps that have been carried out and used in making conclusions based on the exploration of the results in Geogebra.
	Eksplanation	K.1. Reasoning and giving logical reasons about the results of problem solving and conclusions that have been made.
looking back	Self-regulation	R.1. Rechecking the steps that have been taken in problem solving.

Results and Discussion

Description of successful students' critical thinking process in solving Geogebra-assisted linear function problems.

S1 is a student with a successful category in solving linear function problems. Subject answered the problem correctly, critical thinking process indicators achieved were interpretation, analysis, evaluation, inference, explanation and self-regulation. The following subject's answer in figure 2

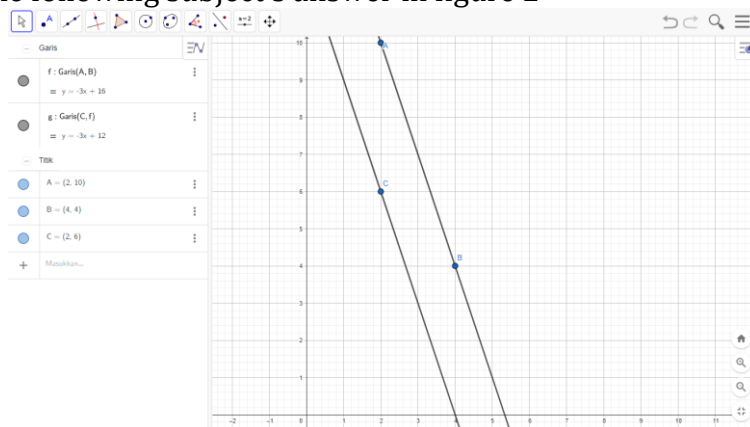


Figure 2. Student answers in the successful category

At the stage of understanding the problem, critical thinking process seen is interpretation. Critical thinking process indicator of interpretation was achieved by S1. This is based on the interview results in Figure 3

P	: Do you understand the problem?
S1	: yes
P	: State what is known and what is asked in the problem?
S1	: Let line g pass through points $D (2,10)$ and $E (4,4)$. Line h passes through point $(2,6)$ and is parallel to line g . Then ask the equation of line h .
P	: What is the main issue in this problem?
S1	: Abdul's statement about the equation of line h , is it true or not.

Figure 3. S1 interview excerpt for the interpretation section

Subject interpreted the information in the problem well. Subject explained the information in the problem and expressed meaning of the statement that was subject matter. Subject stated that the known information is line g through points $D (2,10)$ and $E (4,4)$. Line h through point $(2,6)$ and parallel to line g , then subject determines the equation of line h . Based on this statement S1 can interpret information and problems well. So that the interpretation stage can be achieved well.

At the stage devising a plan, critical thinking process that is seen is analysis. This is based on the interview results in Figure 4

P	: What information can you use to solve the problem?
S1	: Line g passes through points $D (2,10)$ and $E (4,4)$. Line h passes through points $(2,6)$ and is parallel to line g
P	: Why did you use the information to solve the problem?
S1	: After obtaining the equation of the line g , we can find the equation of the line h that is parallel to the line g .

Figure 4. S1 interview excerpt in the analysis section

At this stage, subject connects the information with the concepts that will be used in problem solving with exploration on Geogebra. Subject determined relevant information and considered reasons related to the information to be used in problem solving. Subject explained the information to be used in problem solving, namely line g through points $D (2,10)$ and $E (4,4)$, then line h through point $(2,6)$ and parallel to line g . Subject provided an explanation of the relationship between information needed to be used in solving the problem. Based on this information, equation of line h can be determined. S1 can analyze relevant information and relate to concepts, so S1 can reach the analysis stage well.

At the stage carrying out the plan, critical thinking process that is seen is evaluation, inference, and explanation. This is based on the interview results in Figure 5

P	: What steps or strategies did you choose in solving the problem?
S1	: Find the equation of line h that is parallel to line g using the tools menu in geogebra.
P	: Let's explain systematically, the steps to solve the problem that you have done!
S1	: Write point D and point E on geogebra, then connect point D and point E and obtain the equation of line g . Next, write the point (2,6) and select the parallel line equipment menu and then obtain the equation of the line h is $y + 2x = 12$, then the statement is correct.
P	: What can you conclude from the problem you have done?
S1	: Abdul's statement is correct, based on the results of solving in geogebra the equation of line h is $y + 2x = 12$ and abdul's statement is twice the result obtained in geobra which is $2y + 6x - 24 = 0$.
P	: Why do you believe the statement you made as a conclusion?
S1	: Based on the results of geogebra the equation of line h is $y + 2x = 12$.

Figure 5. Excerpt of S1 interview on evaluation, inference and explanation

Subject determined the steps used in problem solving, namely finding the equation of line h parallel to line g using Geogebra tools. Subject understands what is subject matter and relates the information in problem solving. Based on the exploration process with Geogebra, subject identifies steps that have been taken and used in making conclusions from the statements in the questionnaire that Abdul's statement is correct. Subjects also provide reasons for the conclusions that have been made in accordance with the steps previously taken. So that S1 can reach evaluation, inference and explanation stages well.

At the stage looking back, subject achieved critical thinking process of self-regulation aswell. Subject considers and assesses the results of the answer by rechecking the steps that have been taken in solving the problem correctly. This is based on the interview results in Figure 6.

P	: Did you double check all the steps you took? If yes, which parts did you check?
S1	: Yes, determining the equation of line g and determining the equation of line h through point (2,6) and parallel to line g .

Gambar 6. Kutipan wawancara S1 bagian regulasi diri

Based on the previous results, the critical thinking process in Geogebra-assisted problem solving is concluded as follows. At the stage of understanding the problem S1 interprets the information in the problem. At the devising a plan stage the subject analyzes the information and uses it in problem solving. At the carrying out the plan stage the subject evaluates the problem solving steps in making conclusions and provides logical reasons underlying these conclusions. At the looking back stage the subject re-examines the problem solving steps that have been carried out. Therefore, critical thinking process of successful category subjects shows the achievement of critical thinking process indicators of interpretation, analysis, evaluation, inference, explanation, and self-regulation. this is in accordance with Facione (2015) that a person can achieve critical thinking if they fulfill interpretation, analysis, evaluation, inference, and self-regulation.

Description of critical thinking process of students who are less successful in solving Geogebra-assisted linear function problems.

S2 is a student with a less successful category in solving linear function problems. Subject is less precise in answering the problem, critical thinking process indicators achieved are interpretation, analysis, and evaluation. the following is subject's answer in Figure 7

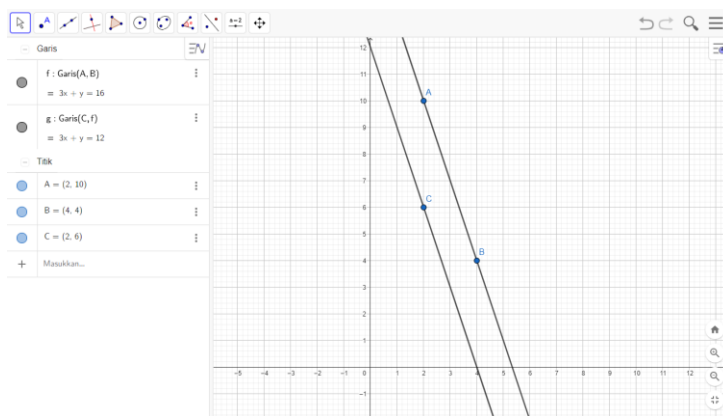


Figure 7. Student answers in the less successful category

At the stage of understanding the problem, critical thinking process can be seen, namely interpretation. Critical thinking process in the interpretation indicator can be achieved well by S2.

P	: Do you understand the problem?
S2	: I understand a little bit
P	: State what is known and what is asked in the problem?
S2	: Let line g pass through points $D (2,10)$ and $E (4,4)$. Line h passes through point $(2,6)$ and is parallel to line g . Abdul says that the equation of line h is $2y + 6x - 24 = 0$.
P	: What is the main issue in this problem?
S2	: Abdul's statement true or not.

Figure 8. S2 interview excerpt for the interpretation section

Subject interpreted the information in the problem well. Subject explained the information in the problem and expressed the meaning of the statement that was subject matter. Subject stated that the known information is line g through points D and E , then line h through point $(2,6)$ and parallel to line g . Abdul's statement became the main problem. Therefore, S2 can reach the interpretation stage well.

At the stage devising a plan, the thinking process that can be seen is analysis. S2 fulfills the indicators of critical thinking process of analysis. This is based on the interview results in Figure 9

P	: What information can you use to solve the problem?
S2	: Line h passes through the point $(2,6)$ and is parallel to line g .
P	: Why did you use the information to solve the problem?
S2	: Can determine the equation of the line h from what is known in the

Figure 9. S2 interview excerpt in the analysis section

S2 connects relevant information that will be used in problem solving, namely line h through point $(2,6)$ and parallel to line g through points D and E with exploration on Geogebra. Subject states that the relevant information is used and explains the reasons for the relevant information can be used to determine the equation of line h using Geogebra. S2 can determine the relevant information used in problem solving well, so that the analysis stage can be achieved well.

At the stage of carrying out the plan, the thinking processes that can be seen are evaluation, inference and explanation. Subject can achieve critical thinking process indicators of evaluation and explanation. This is based on the interview results in Figure 10.

P	: What steps or strategies did you choose in solving the problem?
S2	: Using the parallel line tool in Geogebra.
P	: Let's explain systematically, the steps to solve the problem that you have done!
S2	: Write down point D , point E and point $(2,6)$, then connect points D and E . Then determine the equation of line g with the parallel line tool. Thus, the equation of line h is $3x + y = 12$ and the statement is wrong.
P	: What can you conclude from the problem you have done?
S2	: Statment abdul is wrong
P	: Why do you believe the statement you made as a conclusion?
S2	: based on the results in geogebra
P	: Did you double check all the steps you took? If yes, which parts did you check?
S2	: No

Figure 10. Excerpt of S2 interview on evaluation, inference and explanation

Subject determines the steps used in problem solving. Subject's first step is to write down what is known, namely point D , point E and point $(2,6)$. Then connecting points D and E , the equation of line g is obtained, then using the tools on Geogebra, the equation of line h is $3x + y = 12$. Based on the problem solving steps that have been carried out, the subject can relate any information obtained and used in problem solving so that the evaluation stage can be achieved quite well. In evaluating the exploration process that has been carried out, subject is less precise in making conclusions, namely stating abdul's statement is wrong, this happens because subject does not fully understand the problem in the problem so that the inference indicator cannot be achieved properly. However, subject can provide reasons for the results of the solution that has been done on Geogebra. Students are wrong in making conclusions because students cannot evaluate errors in the previous completion steps (Basri et al., 2019; Sholikha & Siswono, 2023). At the stage looking back, critical thinking process seen is self-regulation. Subject did not consider and assess results of the answer by rechecking steps that had been taken, so there were errors in problem solving. Therefore, subject cannot fulfill the self-regulation stage well.

Based on the problem solving steps that have been carried out, the conclusions of the critical thinking process in Geogebra-assisted problem solving for subjects with the less successful category are as follows. the stages of the thinking process that can be achieved well are interpretation, analysis, evaluation and explanation. Then at the stage of inference and self-regulation is not well achieved. In line with Tajuddin et al. (2023) research, errors occur because students lack focus

in problem solving so that some critical thinking indicators are not well achieved. At the stage of understanding the problem S2 interprets the information in the problem, then at the devising a plan stage subject analyzes the information used in problem solving. At the stage of carrying out the plan the subject evaluates each step of the solution that has been done in making conclusions. Conclusion made by the subject is wrong, but the subject is able to provide logical reasons underlying the conclusion that has been made.

Description of unsuccessful students' critical thinking process in solving Geogebra-assisted linear function problems.

S3 is a student with a unsuccessful category in solving linear function problems. Subject is not precise in answering the problem, indicator of critical thinking process that is achieved is only interpretation. the following is subject's answer in figure 11

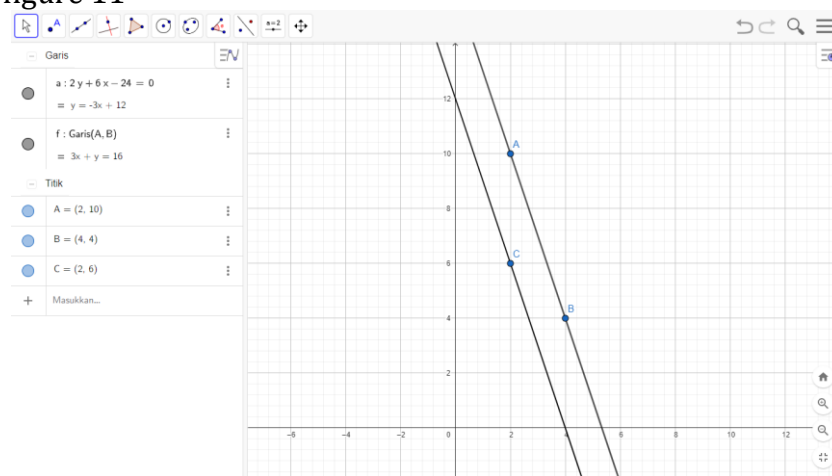


Figure 11. Student answers in the unsuccessful category

At the stage of understanding the problem, it can be seen that critical thinking process, namely interpretation, is quite well achieved. This is based on Figure 12.

P	: Do you understand the problem?
S3	: Slightly understand
P	: State what is known and what is asked in the problem?
S3	: Line g passes through points D (2,10) and E (4,4). Line h passes through point (2,6) and is parallel to line g . Find the equation of line h
P	: What is the main issue in this problem?
S3	: Equation of line h
P	: What information can you use to solve the problem?
S3	: Still confused, I just wrote the known information in Geogebra.

Figure 12. Excerpts S3 interview in the interpretation and analysis section

In interpreting the problem, subject explained the information in problem, namely line g through points D and E. Line h through point (2,6) and parallel to line g . Subject also expressed the meaning of the statement and main problem appropriately, namely determining the equation of line h . S3 can interpret information and problems well, so the interpretation stage can be achieved well by S3.

At the stage devising a plan, critical thinking process seen is analysis. In analyzing, subject did not connect the information with the concepts to be used in problem solving. Subject only wrote down the information in Geogebra without linking it to the concept, so subject also did not explain which relevant information would be used in problem solving. Therefore the subject cannot reach the analysis stage properly.

At the stage carrying out the plan, critical thinking processes that can be seen are evaluation, inference and explanation. This is based on Figure 13.

P	: What steps or strategies did you choose in solving the problem?
S3	: Writing the known in geogebra
P	: Let's explain systematically, the steps to solve the problem that you have done!
S3	: Write the points D and E and connect it, then write the point (-2,3) and the equation $2y+6x+24=0$.
P	: What can you conclude from the problem you have done?
S3	: it looks like Abdul's statement is correct
P	: Why do you believe the statement you made as a conclusion?
S3	: I don't know, see from the picture on geogebra.
P	: Did you double check all the steps you took? If yes, which parts did you check?
S3	: No

Figure 13. Interview excerpt S3 evaluation, inference and explanation section

In evaluating the problem, subject only wrote down the information on Geogebra. subject only wrote what was known in the problem, namely point D, point E and point (2,6) and the equation $2y + 6x - 24 = 0$ without linking the concept of parallel lines in Geogebra tools. In making conclusions, subject only guessed the truth of the statement. Subject only made a guess based on the image from the exploration in Geogebra, then stated that the statement in the problem was true and did not provide logical reasons for the reason it was made. Therefore, subject could not explain the underlying reason for making the conclusion. based on this statement the subject could not reach the evaluation, inference and explanation stages properly. Students still have difficulty in analyzing and evaluating problems so that they are less precise in making conclusions (Fadhilah et al., 2021; Mufidah & Siswono, 2024). At the stage looking back, critical thinking process of self-regulation can be seen. Subject was unable to consider and assess the results of the answer by rechecking the steps that had been taken, so there were errors in problem solving. Therefore, subject cannot fulfill indicators of critical thinking process of self-regulation.

Based on the problem solving steps that have been carried out. It was concluded that the critical thinking process of students in the unsuccessful category was only well achieved at the interpretation stage. At the stages of analysis, evaluation, inference, explanation, self-regulation are not well achieved. In line with Karim & Nurlaelah (2023) research, students' critical thinking skills are low, especially in the evaluation indicator. This happens because students still have difficulty in identifying important information in the problem and linking it to the concepts that will be used in problem solving. At the stage of understanding the problem the subject interprets the information according to what is in the problem. At the devising a plan stage the subject cannot analyze the information properly.

Furthermore, at the carrying out the plan stage the subject makes conclusions only based on conjectures without providing logical reasons.

Based on the results of the study, the achievement of a different critical thinking process was obtained in each subject. At the analysis and evaluation stages Geogebra acts as a medium for student exploration in the problem solving process so that students can develop their critical thinking skills. In line with Negara et al. (2022), through Geogebra students can also find new patterns, explore and then test their conjectures, and manipulate various objects, some of the activities that students can do include designing and drawing their sketches on Geogebra. Therefore, students can develop their critical thinking process in problem solving by using tools on Geogebra. So that this research is expected to provide information to teachers regarding the critical thinking process of students in solving problems of linear function material assisted by Geogebra so that learning can be done that can optimize students' critical thinking processes in accordance with today's technological developments.

Conclusions and Suggestions

Based on the results of the study, the conclusions were obtained. First, the critical thinking process of students in the successful category, students can achieve the stages of the critical thinking process, namely interpretation, analysis, evaluation, inference, explanation and self-regulation well. Second, the critical thinking process of students in the less successful category, students can achieve the stages of interpretation, analysis, evaluation and explanation well. However, at the inference stage, the conclusions made by students are less precise, then students also do not check back. Therefore, the inference and self-regulation stages are not well achieved. Third, the critical thinking process of students with unsuccessful categories is only well achieved at the interpretation stage. So that at the stages of analysis, evaluation, inference, explanation and self-regulation cannot be achieved well. Suggestions from researchers that this research can be developed with a wider scope This research can be developed by analyzing the critical thinking process with other technologies as newer learning media and with different materials.

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